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One size fits all? Drawdown structures in Australia and The Netherlands

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Abstract

Australia and the Netherlands both combine an unfunded non-contributory flat rate pension with prefunded earnings related retirement schemes. Notwithstanding this similarity of structure, however, the two systems are very different. The Netherlands mandates annuitized drawdown structures. In Australia, no prescription, or even guidance, is offered. In both cases, products that better meet the needs of increasingly heterogeneous retirement cohorts are under consideration. We analyze the impact of various popular product choices in the Netherlands and in Australia on the welfare of individuals allowing for different income levels. The study assumes the market return and mortality are stochastic and includes the impact of mean-testing, which reduces the value of the first pillar flat rate. Products offering longevity insurance are the most preferred in the absence of bequest, whereas more flexible portfolios with phased withdrawals score higher when individuals have a bequest motive. The state pension replaces the need to purchase indexed annuities for low income individuals whereas it does not crowd out the demand for longevity insurance for median and high income percentiles. We conclude that the income category, bequests, state pension and risk aversion

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have to be allowed for in any sound welfare assessment of retirement income portfolios since these affect the ranking of portfolios more sharply than mortality differentials and loadings.
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1 Introduction

The Dutch and the Australian retirement systems are widely regarded as amongst the best in the world and highly ranked in the Melbourne Mercer Global Pension Index (MMGPI) (2016). The two countries combine an unfunded non-contributory flat rate pension with prefunded earnings related retirement schemes. Notwithstanding this similarity of structure, however, the two systems are very different in their decumulation stage (García-Huitrón and Ponds, 2015). The Netherlands mandates annuitized drawdown structures (Brown and Nijman, 2012). In Australia, no prescription, or even guidance, is offered (Bateman et al., 2001). Jointly studying these two countries allows us to assess the effect of the institutional setting in the individual's welfare. Our goal is to provide an answer to the following question: '*What is the most welfare enhancing institutional setting for heterogeneous individuals?*'. More specifically, we perform a standardized comparison of retirement portfolios with varying levels of prescription and flexibility in both a defined contribution (DC) and defined benefit (DB) paradigm.

A natural way to analyse the comparability of retirement income products is to perform a welfare analysis, that is, to analyse the utility drawn from a certain retirement income portfolio choice. Commonly, an innovative retirement product is compared to the classical lifetime annuity payout. For instance De Waegenaere et al. (2010); Horneff et al. (2010a) and Post (2012) study the portfolio choice between a classical and a deferred annuity, that is, a product which pays a lifetime income after a contractually specified period conditional on survival. They find that deferred annuities can improve welfare of risk-averse individuals substantially because they insure against increases in annuity prices and provide a smooth income if individuals live longer than expected.

Similarly, Doyle et al. (2004); Milevsky and Kyrychenko (2008) and Horneff et al. (2010b) compare variable with classical annuities and find that individuals should not fully annuitize their wealth, even without bequest motives, and rather enhance their welfare by holding an equity portfolio and matching their consumption with withdrawals. More recently, product innovations such as group self-annuitization (GSA) and phased withdrawals have been considered in Hanewald et al. (2013). They show that a GSA can outperform inflation-linked annuities when there are loadings and that portfolios with phased withdrawals improve individuals' welfare when they have a bequest motive. In the same vein, Boon et al. (2018) show that individuals marginally prefer the GSA scheme over a fairly priced annuity.

In the Netherlands, choice flexibility has not been a part of the pension discussion until very recently (Dellaert et al., 2014). Besides varying the timing of the payout phase, few innovations have been made in the construction of the payments. In particular, flexible payouts such as the 'high-low' and 'low-high' arrangements have been introduced. The first arrangement allows the individual to have a higher payout during the first five years followed by a lower payout during the remainder of their retirement. However, most individuals do not choose this payout construction (Dellaert et al., 2014), and those who do tend to combine it with early retirement to compensate for the lower state pension during the first five years (Willemsen, 2015). Furthermore, the higher payments in early retirement seem to provide the same welfare as taking up to 10% of the pension wealth as a lump sum (van Ewijk et al., 2017). Despite the limited choice and prescription in The Netherlands, both Australians and Dutch have choices to make and preferences are expected to be influenced by their heterogeneous attitude towards risk, income category and mortality (Bateman et al., 2001).

We perform a simulation-based welfare study of retirement product portfolios found in Australia and the Netherlands allowing for individual exposures to equity and mortality risk (Brown, 2001). We assume that the retiree fully consumes the payouts from the retirement portfolio and does not have additional savings following other decumulation risk management studies of Horneff et al. (2008) and Hanewald et al. (2013).[1]. The main implication of this approach is that bequests and consumption, and our comparisons, reflect differing institutional characteristics and resulting drawdown structures, which is the aim of our study.

We study the phased withdrawal, nominal and indexed annuities, and combinations of them for the flexible Australian case. For the Netherlands, individuals can choose either an indexed annuity, 'high-low' or 'low-high' arrangement. We assess the impact of the strength of a bequest motive, annuity loadings and differences in life expectancy for different income categories (commonly known as 'mortality differentials') on individual welfare. We compare the products with respect to the Certainty Equivalent Consumption (CEC), which represents the yearly constant consumption that yields the same utility that the studied portfolio[2], and the Portfolio Equivalent Wealth, which indicates the worth of the retirement income stream.

We consider the welfare gain of including state pensions, means-tested for the Australian setting and flat for the Dutch setting. Generally, means-tested pensions create incentives to reduce wealth in order to have access to government support (Bütler et al., 2017) and to increase the allocation to risky assets, since the state pension acts as a buffer for downside risk (Andreasson et al., 2017). Similarly, life-cycle modeling suggests that individuals will view their means-tested pension as longevity protection, despite the increasing regulatory risk which affects the income and asset tests (Iskhakov et al., 2015).

Our study contributes to the financial planning literature by providing a comprehensive comparison of two institutional settings with distinct features in regards to prescription and government support. The Australian setting pays a means-tested pension and offers the possi-

[1]Deriving an optimal life-cycle strategy for the various portfolios is not the aim of this paper. We compare differing portolios that provide differing consumption profiles and risks within the constraints of the Australian and Dutch retirement systems.

[2]The yearly Certainty Equivalent Consumption in the presence of a bequest is interpreted as the additional income that an individual should receive to give up the life insurance (bequest) component of her portfolio.

bility to create portfolios which combine longevity insurance through the purchase of annuities and equity exposure through phased withdrawal products. The Dutch setting offers a flat pension rate, which serves the purpose of poverty alleviation, and a supplementary lifetime defined benefit income commonly based on lifetime wages. We assess the welfare associated to various portfolios for stylized individuals which have different earnings and mortality expectations. The comparison aims to inform policy by showing the gain associated with offering liquidity options. Partial annuitization remains optimal for most income categories, highlighting the need to develop annuity markets that can share the longevity risk currently borne by the state.

The optimal retirement income product portfolio is shown to be most affected by the bequest motive, means-testing of the first pillar pension and the level of income. Interestingly, mortality differentials and product loadings are less significant factors. In the absence of a bequest, products providing longevity protection are the most welfare enhancing and rank highest in Australia and The Netherlands. A highly prescribed setting, such as the Dutch case, that offers limited choice at retirement may be the most cost-effective in enhancing individual welfare.

The results suggest that a fair annuity from defined contribution retirement wealth can provide higher welfare than the (Dutch) defined benefit product. Once a bequest motive is included, products that provide more flexibility and liquidity rank higher especially for the lowest income percentile. In the presence of a bequest motive, portfolios with partial annuitization are preferred, especially for individuals from the highest income percentile, who live on average longer than the population.

Pricing assumptions that include loadings make annuities less attractive but not enough to be less preferred than a phased withdrawal product in the absence of a bequest. Risk attitude affects the ranking of portfolios, especially for the lowest income percentile. The state pension crowds-out indexed annuities for low income individuals but does not crowd out the demand for longevity insurance for median and high income percentiles. For our assumptions, mortality differentials do not affect the product rankings substantially.

The remainder of the paper is structured as follows. Section 2 describes the modeling of the financial market, mortality risk and utility framework and describes the financial products which will be considered in our analysis. Section 3 presents the data and assumptions used in our analysis and compares the retirement income portfolios for Australia and The Netherlands in the presence and absence of a means-tested state pension. Section 4 studies the sensitivity of our results to risk attitude, subjective discount factor, bequest motive, loadings and mortality differentials. Finally, Section 5 concludes.

2 Model description

In order to compare and assess different retirement plan strategies we consider an array of retirement income products. The shift from benefit-driven pensions to DC increases the uncertainty of the benefits paid to participants during retirement, mainly due to investment and longevity risk. The classical life-cycle literature indicates that a high exposure to equity is beneficial to gain from the stock market and achieve better retirement prospects. A downside of this is that retirement wealth can vary sharply if the markets perform poorly. Similarly, uncertain lifespan needs to be incorporated in an individual's financial planning. Failing to purchase longevity insurance increases the chance that individuals outlive their savings when they live longer than expected.

To include these risks, we assume that participants contribute to a pension scheme and earn a stochastic market return. On and during retirement, they can purchase products providing equity exposure. Retirees have an uncertain lifespan driven by a stochastic mortality model that is suitable for modelling higher ages. The welfare for individuals of the retirement portfolios for Australia and the Netherlands assumes Constant Relative Risk aversion preferences for consumption and bequests. We incorporate the first pillar state pension to assess the interaction between the government subsidy and the products available in the private market.

2.1 Financial market

Contributions to a pension fund are assumed invested in a financial market with two assets: a money market account paying a risk-free constant return r and a risky equity index earning a risk premium. The risky equity index S_t at time t is modeled with a geometric Brownian motion as follows:

$$dS_t = \mu \cdot S_t \cdot dt + \sigma \cdot S_t \cdot dZ_t, \tag{2.1}$$

where μ is the drift term and is equal to $r + \lambda \cdot \sigma$ where $\lambda \cdot \sigma$ is the risk premium parameter and σ is the stock price volatility. The initial value of the fund is given by S_0. The annual return for the period $t-1$ to t on the account balances invested in equity during the individual's working career and retirement can be determined as follows:

$$i_t = \frac{S_t - S_{t-1}}{S_{t-1}}. \tag{2.2}$$

2.2 Life table

We incorporate stochastic mortality so that an individual has an uncertain lifespan upon retirement that incorporates both individual and aggregate or systematic mortality risk. The survival probabilities are assumed to follow a Cairns, Blake and Dowd (CBD) model (Cairns et al., 2006, 2009) which is fitted to the Australian and Dutch historical mortality experience from the Human Mortality Database (2014, 2015). The CBD model is considered suitable for modelling higher ages and has a relatively simple structure and few parameters. The CBD model smooths mortality rates by age using a logit of the one year mortality probabilities, as shown below:

$$logit\left(q_x(y)\right) = \log\left(\frac{q_x(y)}{1-q_x(y)}\right) = \kappa_y^{(1)} + (x-\overline{x})\kappa_y^{(2)}, \tag{2.3}$$

where

$q_x(y)$ is the probability that an individual aged x at time y will die between y and $y+1$ before attaining age $x+1$,

$\kappa_y^{(1)}$ and $\kappa_y^{(2)}$ represent period-related effects, and

$\overline{x}$ is the average age in the population considered.

The one-year death and survival probability are linked through the following expression $p_x(y) = 1 - q_x(y)$. The probability that an individual survives to age t in year $y+t-s$ conditional on being alive at age s in year y can be expressed as follows:

$$_{t-s}p_s(y) = \prod_{j=0}^{t-s-1}\left(1-q_{s+j}(y+j)\right) = \prod_{j=0}^{t-s-1} p_{s+j}(y+j). \tag{2.4}$$

Mortality is heterogeneous and depends on sex, education, income and marital status among others factors (Kaplan et al., 1996; Deaton and Paxson, 2001; Brown and McDaid, 2003). Insurers and retirement income providers have long been interested in what is known as 'basis risk', namely the fact that the life tables of the population differ from those of their insured portfolios (Millossovich et al., 2014; Villegas and Haberman, 2014). In particular, recent research shows that differences in life expectancy can be up to 10 years between socio-economic groups of the general population and pensioners and annuitants in pension schemes in the United Kingdom (Madrigal et al., 2011; Office for National Statistics, 2014). We price the annuities with the life table from the general population but we assume that mortality differs across income categories. In particular, following Madrigal et al. (2011), we assume that the individuals from the highest and lowest income categories have a lower or higher mortality than the average population respectively. Mathematically, this is expressed as follows:

$$p_x^{ic}(y) = \eta^{ic}\cdot p_x(y), \tag{2.5}$$

$$\eta^{ic} = \frac{\mathring{e}_{x:\overline{n}|}^{ic}}{\mathring{e}_{x:\overline{n}|}}, \tag{2.6}$$

where

η^{ic} is a constant which alters the life table for each income category. It is obtained as the ratio of the life expectancy of the income category ic, $\mathring{e}_{x:\overline{n}|}^{ic}$, over the life expectancy of the total population $\mathring{e}_{x:\overline{n}|}$. A value of η^{ic} higher or lower than one indicates that the income category ic has a higher or lower average survival respectively. This multiplicative approach implies that the relative difference in survival is equal across all ages, although empirical evidence suggests that the difference in mortality between socio-economic categories narrows at older-ages (Madrigal et al., 2011).

2.3 Welfare

Discounted expected utility at retirement is used to assess welfare of retirement income product portfolios. The only source of income for the retiree is the retirement income purchased from retirement savings complemented by a first pillar flat-rate pension. We perform the analysis for an individual retiring at age x_r, set equal to 65, in year y. To simplify the notation the year is set to $y = 0$:

$$V(k_0) = \mathrm{E}_0 \left[\sum_{t=0}^{\omega - x_r} \beta^t \left({}_t p_{x_r}(0) u(c_t) + {}_{t-1} p_{x_r}(0) q_{x_r+t-1}(t-1) b(k_t) \right) \right], \tag{2.7}$$

where k_t represents the wealth at age $x_r + t$, β is the subjective discount factor, and ω is the last surviving age. The expression ${}_t p_{x_r}(y)$ is the probability that an individual survives to age $x_r + t$ in year t conditional on being alive at age x_r in the retirement year 0 as in Equation (2.4) and $q_{x_r+t-1}(t-1)$ is the probability of someone aged $x_r + t - 1$ at time $t - 1$ dying in the period $t - 1$ and t.

Furthermore, $u(c_t)$ represents the utility function for consumption and $b(k_t)$ corresponds to the utility from bequest, given as follows for Constant Relative Risk Aversion (CRRA) preferences:

$$u(c_t) = \frac{c_t^{1-\gamma}}{1-\gamma}, \tag{2.8}$$

$$b(k_t) = \alpha \frac{k_t^{1-\gamma}}{1-\gamma}, \tag{2.9}$$

where γ is the risk aversion coefficient and α is the strength of the bequest motive. The risk aversion coefficient describes the willingness to substitute consumption across different states of the world. A coefficient of α equal to 0 indicates the absence of a bequest motive. In this case the individual gains utility solely from consumption.

2.4 Institutional setting

The Australian and Dutch institutional settings share key design features. Both offer a flat-rate first pillar pension payment whose main purpose is to serve as a poverty alleviation mechanism. The second pillar, on the other hand, relies heavily on savings and provides supplemental income. The two countries are commonly grouped together as pension schemes of the *Beveridgean*, Anglo-Saxon, type.

Their aim and design differs substantially from other types, such as the *Bismarckian* model which offers earnings-based retirement benefits (Esping-Anders, 1990). A closer analysis of the choice architecture suggests to group prefunded pension schemes in four classes: *Induced Choice*, *Regulated Choice*, *Delegated Choice* and *Centralized choice* (García-Huitrón and Ponds, 2015).

The Australian and Dutch settings are considered as countries with restricted choice during the accumulation phase compared to pension schemes with maximal or no choice. Examples of the former include the United States and New Zealand where participation is voluntary but induced by behavioral mechanism such as defaults and commitment devices. Malaysia or Singapore, on the other hand, mandate participation and leave little room for individual choice.

In Australia, it is compulsory to make contributions to a Superannuation fund if the earnings criteria are fulfilled. In the Netherlands, it is not mandatory to participate[3] and the choice is aggregated in pension contracts that are negotiated by representative agents.

However, the similarities in coverage and choice architecture disappear when looking at the decumulation phase. In the Netherlands, pensions need to be taken as lifetime retirement income streams whereas in Australia there is no prescription to convert the retirement wealth in products providing longevity protection. The remainder of the section provides details on the accumulation and decumulation of retirement wealth within the Australian and Dutch pension schemes.

2.4.1 Australia

Participants in the pension scheme contribute the statutory contribution rate of $\pi = 9.5\%$ from their wages $w_{x,s}$ at age x and time s to their superannuation fund[4] between age x_0, when they start their working career, and $x_r - 1$, which is the period before the (fixed) retirement age. The contributions paid earn equity return i as in Equation 2.2. Wealth at retirement k_0 is determined by compounding the yearly contributions using:

$$k_0 = \sum_{x=x_0}^{x_r-1} \pi \cdot w_{x,x-x_r} \prod_{j=x+1}^{x_r} (1 + i_{x-x_r}) . \tag{2.10}$$

We abstract from the tax arrangements in Australia, despite them having an effect in the accumulated balance at retirement[5]. Upon retirement, individuals decide to purchase a retirement income product (or a portfolio of products) to finance their spending at retirement.

The individuals choose between three different products which are commonly offered to Australian retirees. The first is a nominal life annuity, the second an indexed life annuity and the third a phased withdrawal arrangement. The first two products offer longevity insurance at the expense of flexibility and bequest while the latter offers flexibility in the drawdown pattern

[3]In practice, 90% of the employees are covered by an occupational pension scheme (Bateman et al., 2016).

[4]Even though this percentage was lower in the past we assume 9,5% throughout the career.

[5]Australia has a 'TTE' approach to taxation, that is, contributions and their return are taxed during the accumulation phase and the retirement income product at retirement is exempted (Kudrna and Bateman, 2014). In the Netherlands, tax exempt pension savings are in terms of accrued pension rights rather than contributions. Rights accrued on top of a certain threshold are therefore taxed. During retirement, the pension is subject to income tax (Bateman et al., 2016).

and the possibility to bequest at the expense of not providing longevity insurance. Phased withdrawals, also known as Account-based pensions in Australia, are currently by far the most popular retirement income product for Australians (Bateman and Piggott, 2011; Iskhakov et al., 2015).

The individual has the possibility to create a portfolio of products in order to obtain both longevity insurance and flexibility. We denote by θ_1, θ_2 and $\theta_3 = 1 - \theta_1 - \theta_2$ the proportion of the pension wealth used to purchase a nominal annuity, indexed annuity and phased withdrawal product respectively. At the time of purchase the individual aged x_r is offered an annuity based on their wealth and the annuity factor as follows:

$$a_{s,\delta} = (1+l)\,\mathrm{E}_{x_r}\left[\sum_{x=x_r}^{\omega} {}_{x-x_r}p_{x_r}(0)\left(\frac{1+\delta}{1+r}\right)^{x-s}\right], \tag{2.11}$$

where l is the loading rate which increases the value of the annuity factor, decreasing the regular annuity paid. It can be considered a proportional premium attached to the contract for the insurer to finance expenses, transaction costs and unhedgeable risks (Mitchell et al., 1999). A value of $l = 0\%$ corresponds to a fairly priced annuity. The parameters δ and r correspond to the indexation rate during retirement and the discounting rate used in the annuity calculation, respectively. Note that $\delta = 0$ for a nominal fixed annuity.

The consumption associated with a nominal annuity, C_t^A, is calculated with a nominal annuity factor $a_{x_r,0}$ whereas the consumption related to indexed annuity, C_t^{iA} is calculated with the indexed annuity factor $a_{x_r,\delta}$. During retirement, the consumption evolves as follows:

$$C_t^A = \theta_1 \frac{k_0}{a_{x_r,0}}, \tag{2.12}$$

$$C_t^{iA} = \theta_2 \frac{k_0}{a_{x_r,\delta}}\,(1+\delta)^t, \tag{2.13}$$

Finally, the phased withdrawal product allows the policyholder to regularly withdraw a specified amount from their superannuation fund net of other retirement purchases until it is depleted. The withdrawal rates, denoted by ψ, may depend on the age and statutory regulations on minimum withdrawals. The consumption associated with the phased withdrawal, C_t^{PW}, is as follows:

$$C_t^{PW} = \psi_{x_r+t}\cdot k_t^{PW} = \psi_{x_r+t}\cdot\theta_3\cdot k_0\prod_{j=0}^{t-1}\left(1-\psi_j\right)\left(1+i_{j+1}\right). \tag{2.14}$$

2.4.2 The Netherlands

The Netherlands has no mandated minimum pension contribution and legislation only stipulates the maximum pension rights that an individual can accrue annually. Despite the recent waves of reforms towards more flexibility (Bovenberg and Nijman, 2012), most individuals in the Netherlands are in defined benefit plans that provide around 75% of their average lifetime salary with 40 years of employment (Bateman et al., 2016). In practice, most individuals contribute a fixed rate of 17% of their wages to the retirement scheme, independent of their income level, age or sex (Bateman et al., 2016). Since the benefits paid during retirement are earnings-based and not contribution-based, we do not consider the impact of contributions. Most pension funds in the Netherlands have a threshold in the accumulation phase, usually set at the level of the state pension, on top of which individuals accrue pension rights. Therefore, individuals earning less than the annual state pension do not accrue second pillar benefits and rely solely on the state pension.

At retirement, individuals receive a lifetime payment based on the pensionable salary PS_{x_r} which is calculated as the average earnings above the threshold for the last 40 years. Past contributions are indexed to the year of retirement value with the Consumer Price Index. The array of products is reduced to three indexation-linked lifetime incomes since Dutch legislation makes full annuitization compulsory (Bateman et al., 2016). Individuals can choose between a 'high-low', 'low-high' and a classical inflation indexed payment. The 'high-low' arrangement provides 100% of their retirement entitlement in the 'high' stage from ages 65 to 70 and 75% during the 'low' stage from 70 years onwards[6]. The third product consists of an indexed annuity. The indexation rate paid during retirement, denoted as δ is based on the inflation set by the Centraal Bureau voor de Statistiek (2017). Mathematically, the retirement payout during retirement is expressed as follows:

$$C_t^{h,l} = \begin{cases} P_t^{h,l} = P_{x_r}^{h,l}\,(1+\delta)^t & \text{if } t \in [0,4]; \\ 75\% \cdot P_5^{h,l} & \text{if } t = 5; \\ 75\% \cdot P_5^{h,l}\,(1+\delta)^{t-5} & \text{if } t \in [6, \omega - x_r]. \end{cases} \tag{2.15}$$

$$C_t^{l,h} = \begin{cases} P_t^{l,h} = 75\% \cdot P_{x_r}^{h,l}\,(1+\delta)^t & \text{if } t \in [0,4]; \\ P_5^{h,l} & \text{if } t = 5; \\ P_t^{h,l}\,(1+\delta)^{t-5} & \text{if } t \in [6, \omega - w_r]. \end{cases} \tag{2.16}$$

$$C_t^{iDB} = 75\% \cdot PS_{x_r}\,(1+\delta)^t\,, \tag{2.17}$$

where $P_{x_r}^{h,l}$ is the first pension paid in the 'high-low' environment, during the 'high' stage from retirement age x_r to age x_r+5 and $P_{s,y}^{l,h}$ is the first pension paid in the 'low-high' arrangement and corresponds to 75% of the high pension paid after 5 years. The Dutch system pays typically defined benefit pensions. To correctly calculate the 'high-low' and 'low-high' entitlements, we first calculate the wealth which is equivalent to the yearly pensionable salary entitlement PS_{x_r}. Then we divide this wealth by a suitable annuity factor that accounts for the variation in the income pattern. For instance, for the 'high-low' pension the entitlement at retirement is calculated as follows:

[6]7 Artikel 63, lid 1.a Pensioenwet.

$$P_{x_r}^{h,l} = \frac{PS_{x_r} \cdot a_{x_r,\delta}}{\sum_{x=x_r}^{x_r+4} {}_{x-x_r}p_{x_r}(0)\left(\frac{1+\delta}{1+r}\right)^{x-x_r} + 75\% \sum_{x=x_r+5}^{\omega} {}_{x-x_r}p_{x_r}(0)\left(\frac{1+\delta}{1+r}\right)^{x-x_r}}. \tag{2.18}$$

2.5 State Pension

Australia and The Netherlands state pensions pay a flat-rate income throughout retirement to all residents regardless of their wages during their career. There are some differences between the two countries. In The Netherlands the payment is applicable to all individuals regardless of income or asset status and only depends on the number of years that they have lived in the country. Retirees receive a full payment if they live in the Netherlands for at least 50 years. The gross amounts as from 1 January 2017 are 13,840.20€ for a single and 19,070.16€ for a couple per year (Social Security Bank (SVB), 2017). We consider in our analysis an individual who has lived in the Netherlands for the past 50 years, so they receive the full benefit.

On the other hand, Australia has a more complex system (Chomik and Piggott, 2014). All Australian residents who have lived in Australia for at least 10 years have the right to receive the full payment. The state pension paid to an individual, if any, is determined by an income and assets means test. The more assets an individual owns and the higher the income she has during retirement, the lower the government state pension received. The maximum monthly gross rates paid from 1 January 2017 are $21,015.80 for singles and $31,683.60 for a couple (Department of Human Services, 2017a). Details on the state pension are provided in Appendix A.

3 Retirement System Comparisons

3.1 Data and parametrization

We present the model calibration and parameters used in our portfolio comparison. We consider the case of an individual who enters employment at $x_0 = 18$ and retires at $x_r = 65$. At retirement, individuals purchase a retirement income portfolio based on the two institutional settings. For Australia, a means-tested pension is combined with an array of portfolios offering varying levels of longevity protection and flexibility. We also consider the case where they have access to a flat-rate state pension which is not means-tested and accrues defined benefit rights. They are exposed to mortality during retirement until they either pass away or live to the maximum age of $\omega = 110$. The financial market, welfare function, earnings profiles and mortality assumptions for our study are briefly discussed here.

Pension funds and retirement income providers take on equity risk in the accumulation and decumulation phase with account balances invested into a fund with equity exposure (Bovenberg and Nijman, 2012). From an individual's perspective, equity risk exposure depends on whether the accumulation is in defined contribution or defined benefit funds. The Australian setting studied has equity exposure through the phased withdrawal retirement product. The Dutch, on the other hand, do not typically have equity exposure[7]. The drift term μ is equal to $r + \lambda \cdot \sigma = 7.96\%$ where $\lambda = 0.22$, $\sigma = 0.18$ and $r = 4\%$, which aligns with recent welfare studies (Hanewald et al., 2013; Horneff et al., 2014; Boon et al., 2018).

The survival and death probability are calibrated with the Cairns-Blake-Dowd (CBD) model presented in Section 2.2 for the Australian sample[8]. Following Madrigal et al. (2011), we assume that mortality differs across income percentiles. The factor η^{ic} affecting the average survival probability in Equation (2.5) is equal to 0.9271 for the lower income percentile $ic = 10^{th}$ and 1.13 for the higher income percentile $ic = 90^{th}$[9]. That is, the individuals from the highest income percentile are expected to live 13% longer than the average population and the individuals in the lower income percentile are expected to live 7% shorter.

We assume the same mortality differentials in The Netherlands and Australia since no country-specific data is available and both countries have a similar Human Development Index (United Nations Development Programme, 2016)[10]. However, the higher inequality in Australia could lead to increasing mortality differentials between individuals from different income categories[11].

We calculate the superannuation wealth in Australia and the defined benefit for the Netherlands for the the 10^{th} percentile, median and 90^{th} percentile. We use the gross earnings per income percentile and age category from the Australian Bureau of Statistics (2016a)[12]. Whenever euro amounts are shown, these are calculated by converting Australian dollars to euros assuming Purchasing Power Parity (PPP)[13]. By doing this, we reduce the disparities caused by

[7]DB pensions are commonly indexed to the Consumer Price Index or wages. In practice, indexation in the Dutch system depends on the solvency of the pension fund, that is, indexation is "*granted if the asset value of the fund is sufficient to cover all future obligations* as stated in De Jong (2008). Kortleve (2013) and Bovenberg et al. (2016) indicate that this solvency-dependent indexation was introduced after the global financial crisis to correct for an increasing exposure of pension funds to market and demographic risks. A stochastic or solvency-linked indexation would add another layer of uncertainty, decreasing the attractiveness of inflation-linked products.

[8]We estimate the model for the Dutch sample too. However, we only use the Australian estimation in our analysis to ensure a standardized comparison between the institutional settings. Our results are still applicable to the Dutch population as the Australian and Dutch survival curves and life expectancies are very similar (see Appendix B)

[9]These values are obtained as the ratio between the life expectancy for the salary band £48.5K for the highest percentile or <£15K for the lowest income percentile over the life expectancy for the salary band £22,5K-£30.5K corresponding to the middle income range. We assume that the individuals belong to the same geo-demographic group C-middle and that their only difference is the earned wage.

[10]Australia has a Human Development Index of 0.939 while The Netherlands has an index of 0.924 (United Nations Development Programme, 2016).

[11]The Gini coefficient, commonly used to measure inequality, indicates that Australia is more unequal than the Netherlands since their Gini value of 0.337 lies above the Dutch's Gini coefficient of 0.283 (OECD, 2017a).

[12]The Australian Bureau of Statistics publishes the employee gross earnings every year from 1993 to 1995 and every two years for the period between 1996 and 2016. However, most datasets prior to 2014 do not provide information on the income percentiles per age category.

[13]The Purchasing Power Parity rates allows us to "... *equalize the purchasing power of different currencies by eliminating the differences in price levels between countries.*" (OECD, 2015). The PPP value

inequality and country-specific wage profiles. Superannuation savings at retirement requires an individual's wages since entry to the pension scheme as in Equation (2.10). Due to the unavailability of reliable data before 2014 for income percentiles, we obtain past wages by adjusting the values as of 2014 using historical CPI (Australian Bureau of Statistics, 2016b).

Finally, the inflation rate which affects the evolution of the means-test threshold presented in Section 2.5 and indexed annuity in Equation (2.13) is set to 2.5% as indicated by the Reserve Bank of Australia (2017)[14].

For the phased withdrawal product, we assume that individuals follow the minimum withdrawal percentages required by the Australian Taxation Office (2017). This aligns with the behavioral economics literature which suggests that defaults influence savings and investment behavior in pension plans (Beshears et al., 2009, 2011). The withdrawal rates as a percentage of the remaining balance increase with age as calculated by Australian Taxation Office (2017)[15].

We assume a subjective discount factor of 1.5%, that is a $\beta = 0.9855$ which aligns with the real risk free rate of 1.5%. In the sensitivity analysis we will analyse a subjective discount factor of $\beta = 0.98$ in line with recent welfare studies (Feldstein and Ranguelova, 2001; Post, 2012; Hanewald et al., 2013; Boon et al., 2018) and $\beta = 0.991$ to assess the effect of impatience. Three levels of risk aversion coefficients are considered which represent low risk aversion, $\gamma = 2$, moderate risk aversion $\gamma = 5$ and high risk aversion, $\gamma = 8$. Finally, the bequest coefficient α is set equal to 0.15, indicating that individuals enjoy leaving a bequest half as much as they enjoy consuming in the same period. As coefficient of 0 indicates that the individual does not desire to leave a bequest to their heirs and a coefficient of 1 indicates that they draw the same utility from leaving a bequest as they do from consumption.

3.2 Portfolio comparison

Table 1 shows the portfolios which are considered for the Australian and Dutch case. As indicated in the introduction, we assess portfolios of products based on diversification heuristics, as often observed in the empirical literature[16]. For instance, Benartzi and Thaler (2007) find a strong reliance on heuristics, with a clear peak to allocate $\frac{1}{n}$ of their wealth among n different products or assets. More recently Bateman et al. (2017), in an Australian context, show that a third of the participants in an online experimental survey choose to annuitize half of their wealth and keep the other half in a flexible phased withdrawal account when presented with two retirement products.

corresponds to 0.58 in our case, that is, 1 Australian dollar is PPP equivalent to 0.58 Euros.

[14] The value of 2.5% lies between the 2 and 3% that the Governor and the Treasurer of the Reserve Bank of Australia consider an appropriate target for monetary policy in Australia.

[15] The minimum withdrawal rates are 4%, 5%, 6%, 7%, 9%, 11% and 14% for retirees aged 55-64, 65-74, 75-79, 80-84, 85-89, 90-94 and older than 95 respectively.

[16] We do not compute the optimal proportions in each retirement product since we aim to show results for representative portfolios, and in any event optimal portfolios reflect model specifications rather than actual portfolios.

Table 1: Retirement income portfolios for Australia and The Netherlands.

	Australia				The Netherlands		
	Nominal Annuity	Indexed Annuity	Phased Withdrawal		Indexed Annuity	High/Low	Low/High
1	100%	0%	0%	1	100%	0%	0%
2	0%	100%	0%	2	0%	100%	0%
3	0%	0%	100%	3	0%	0%	100%
4	50%	50%	0%				
5	50%	0%	50%				
6	0%	50%	50%				
7	33%	33%	33%				

Notes: Note that we do not consider product mixes for the Netherlands since all three products are income-based only.

To compare the various portfolios, we compute the utility cost measured in consumption equivalent units as in Cocco et al. (2005). The utility cost is defined as the change in the 'Certainty Equivalent Consumption' (CEC) when deviating from the nominal annuity portfolio[17]. This is done to assess the losses or gains incurred if deviating from the long-standing recommendation to fully annuitize their wealth and the optimal product when we abstract from the bequest motive[18]. The CEC corresponds to the constant consumption stream that makes the retiree indifferent between receiving a constant payment and consuming the purchased retirement income portfolio and, if relevant, leaving a bequest to their estate. Mathematically, it is determined as follows:

$$\overline{U} = \mathrm{E}\left[\sum_{t=0}^{\omega-x_r} \beta^t {}_t p_{x_r}(0) \frac{CEC^{1-\gamma}}{1-\gamma} + \beta^t {}_{t-1}p_{x_r}(0) q_{t-1}(t-1)\alpha \frac{(k_t)^{1-\gamma}}{1-\gamma}\right], \tag{3.1}$$

where $\overline{U}$ is the utility in (2.7) of a retirement portfolio. Note that the wealth k_t depends directly on the difference between the payment related to the retirement income portfolio P_t and the implied CEC as follows:

$$k_t = k_0 \prod_{j=1}^{t} (1 + i_{j+1}) + \sum_{k=0}^{t-1} (P_t - CEC) \prod_{j=1}^{t} (1 + i_{j+1}) \,. \tag{3.2}$$

If the retiree has the desire to leave a bequest to their estate, the CEC will capture that by varying the (certain) consumption level. Indeed, the yearly difference between the CEC for

[17]Cocco et al. (2005) calculate the utility cost by assessing the change between the studied portfolio and the optimal investment rule.

[18]The portfolio with full annuitization is closely related to the optimal annuitization in the absence of a bequest motive Yaari (1965).

participants with a bequest motive and the CEC without corresponds to the amount that the individual would request to give up the life insurance on the remaining wealth contingent on death. We use the 'Equivalent Wealth' (EW) to measure the welfare too, to investigate the (non-annuitized) monetary value of the reference portfolios. It is calculated as the retirement wealth which is equivalent to the CEC.

The remainder of this Section presents the analysis for our benchmark case for three income categories. We do not consider annuity loadings but include the assumption that the individuals from the highest and lowest income percentile live on average 13% longer and 7% less long, respectively, than the median income category. We assess the utility cost of a stylized retiree in both the Australian and Dutch institutional settings. Finally, we show the effect of the state pension, in particular of our comprehensive means-test, in the demand of retirement income portfolios. Sensitivities to individual preferences, such as the existence of a bequest motive or varying levels of risk aversion, pricing assumptions, such as loadings and mortality differentials and sensitivities to the β coefficient are analysed in Section 4.

3.3 Flexibility versus prescription: a standardized comparison

We consider two institutional settings, the Australian or Dutch pension schemes. The former is a proxy for a flexible retirement income arrangement with a wide array of products. The state pension is means-tested and the wealth at retirement corresponds to the yearly contributions made during the participant's career. These contributions are based on the total yearly earnings and are not capped. The alternative is to be in the Dutch setting with a defined benefit pension and a state pension which is not means-tested. The defined benefit income is based on the yearly earnings on top of a threshold, set equal to the state pension. This highlights the role of the second pillar as a source of supplementary income on top of the guaranteed state pension.

To ensure the comparability of our results, we perform the study for stylized Australian individuals. The earnings, wages, inflation and life table correspond to Australian case. In this section we consider that the retiree has a risk aversion coefficient of $\gamma = 5$. We consider seven portfolios offering varying levels of longevity protection and flexibility from the Australian setting and the three lifetime income products from the Dutch system presented in Section 2. The utility cost measures the change in yearly CEC or equivalent wealth between the studied portfolio and the (fair) nominal annuity.

Table 2 summarizes the welfare measures for the benchmark case with three income categories and two bequest scenarios. The first row of each block presents the percentage variation on the *Equivalent Wealth* between the nominal annuity (portfolio 1) and the remaining six Australian portfolios and three lifetime income choices for The Netherlands. The second row of each block presents the *Equivalent Wealth* that corresponds to the wealth at retirement that yields the same utility as the retirement income portfolio.

The difference between the *Equivalent Wealth* with and without a bequest can be interpreted as the additional wealth at retirement that should be paid to an individual to give up their liquidity or bequest motive. For instance, the bequest motive for a retiree with the median wage is worth an additional \$ 479,000 dollars.

Firstly, we observe that, in the absence of a bequest motive, all retirement portfolios considered have a negative utility cost. This indicates that, among the studied portfolios, an individual would be advised to fully annuitise her wealth to achieve the highest utility levels. This aligns with the literature on optimal annuitization without bequest motives stemming from Yaari (1965). However, if she were to choose between a nominal and indexed annuity, she would be slightly better off with the nominal stream in all scenarios. The indexed annuity, per design, provides a lower initial pension as the annuity factor is larger than the (fair) nominal annuity factor because pre-loads the indexation during retirement. The lifetime loss associated with choosing the indexed defined contribution annuity instead of the nominal ranges from \$ 24,000 for the lowest income to \$ 118,000 for the highest income percentile.

Note that the (DC) indexed annuity yields a higher welfare than the (DB) indexed annuity commonly provided in The Netherlands. In the former, the annuity is based on the accumulated wealth and a fair annuity factor, whereas the latter is based on a defined benefit formula which accrues pension rights on top of the state pension threshold. Even those most affected by the means-test, are still best off with a lifelong payment based on a defined contribution arrangement rather than the defined benefit scheme with the 75% replacement rate rule.

The recent product innovation in the Netherlands in the form of a 'high-low' and 'low-high' payment have the lowest level of *Equivalent Wealth* and highest utility cost. However, there are slight differences between the three products. Table 2 indicates that the 'high-low' construction is the most welfare enhancing product while the least is the 'low-high' construction. Note, however, that innovations such as the 'high-low' or 'low-high' constructions marginally increase welfare, especially for the lowest income categories.

The utility loss is greatest for individuals with no bequest motive investing their retirement wealth fully in a phased withdrawal product. The higher the share of phased withdrawal, the higher the cost. Australians, without bequest motives, currently take lump-sums or phased withdrawals at a much higher rate than they take annuities (Iskhakov et al., 2015; APRA, 2015) are less well off by between \$ 93,000 and \$ 573,000, depending on their income category, during their lifetime.

Individuals with a bequest motive see their preferences vary quite sharply. Table 2 shows two effects of considering the desire to leave a bequest. First, the lifetime *Equivalent Wealth* for portfolios with full annuitization, either nominal or indexed, does not vary when the individual has a bequest motive. This follows as the initial wealth is fully used to purchase the income stream and we do not allow for saving. Second, portfolios with a phased withdrawal component (portfolio 3, 5, 6 and 7) experience a remarkable utility gain compared to purchasing a nominal annuity ranging between 17% and 30%. We observe that portfolios with longevity protection and no bequeathable assets have the lowest *Equivalent Wealth*, making the portfolios with equity exposure in the phased withdrawal product more desirable. These results are robust to an increase of the desire to bequest[19]. The welfare gain, and preference for a portfolio with equity exposure, increase with the bequest motive, especially for the lowest income category.

The payment from the government, which is indexed, partially crowds out the demand for the indexed and nominal annuity as shown in the results for portfolio 5, 6 and 7 in Table 2. Indeed, the gain from choosing these portfolios increases with the income percentile since the potentially lower payment from the government as income and wealth increase, needs to be compensated with retirement income products providing longevity insurance. These insights align with the literature on the impact of means-testing pensions in financial planning. The limited literature on this topic suggests that a means-tested pension lowers annuitization rates, especially for lower and median incomes (Bütler et al., 2017).

The inclusion of the bequest motive mimics the observed purchase of phased withdrawal products in Australia more closely for the risk aversion coefficient considered. The full annuitization in the case without bequest, and high annuitization rates with a bequest motive suggested by our welfare measures align with most of the classical literature but contrast with the empirical evidence that annuitization is rare. The low annuitization rates observed have led researchers to find solutions to this so-called 'annuity puzzle'. Life-cycle studies including fees and expenses associated with annuities, incomplete annuity markets, that is, markets with annuities that do not necessarily match an individual's consumption desires, or background risk still yields high annuitization rates, even for individuals with bequests motives (Mitchell et al., 1999; Davidoff et al., 2005; Peijnenburg et al., 2016)[20].

More recently, researchers have found explanations that can lead to lower annuitization. In particular, adverse selection, pre-existence of Social Security or health risk can explain the low annuitization levels (Hosseini, 2015; Peijnenburg et al., 2016, 2017). These justifications rely on comprehensive (theoretical) life-cycle models. However, recent experimental studies show that an (intended) bequest motive is the least preferred motive to hold liquid wealth during retirement, whereas self-gratification or precautionary health expenditures score higher (Alonso-García et al., 2017).

In our setting, the higher utility drawn from holding liquid wealth could be serving various purposes: ability to self-insure against unexpected health expenditures, build-up precautionary savings to secure leisure-related consumption at later stages of retirement and leave the remaining wealth to the heirs or estate. The duality of the bequest motive modeled would align with the findings of Lockwood (2014). He argues that individuals accumulate wealth to self-insure health and longevity risks, building up high precautionary savings, *since* they also value leaving a substantial bequest.

[19] We do not show the results for higher levels of bequest as the interpretation is comparable.

[20] Please refer to Benartzi et al. (2011) and Benartzi and Thaler (2007) for a review of the literature on the rational and behavioral motives, respectively, that drive retirement savings behavior and the annuity puzzle.

Table 2: Flexibility versus prescription: Percentage variation between the nominal annuity portfolio (portfolio 1) and the retirement portfolios presented in Table 1 [first line] and the initial ‘Equivalent Wealth’ (in $ ’000s) [second line].

		Australian							Dutch		
Income category	Bequest	Nominal Annuity	Indexed Annuity	Phased Withdrawal	Mixed Annuities	Nominal Annuity, Phased Withdrawal	Indexed Annuity, Phased Withdrawal	Third each	Indexed Annuity (DB)	High/Low Annuity	Low/High Annuity
P10		0	-4	-14	-2	-5	-8	-4	-32	-32	-32
		659	635	566	**649**	623	609	629	445	446	445
P50	No	0	-5	-22	-2	-7	-11	-6	-32	-30	-34
		1,200	1,137	941	**1,182**	1,116	1,070	1,133	818	834	789
P90		0	-5	-23	-1	-7	-10	-5	-36	-34	-40
		2,444	2,326	1,871	**2,424**	2,282	2,188	2,328	1,575	1,611	1,479
P10		0	-4	21	-2	26	24	24	-32	-32	-32
		659	635	799	649	**832**	814	**817**	445	446	445
P50	Yes	0	-5	18	-2	30	25	28	-32	-30	-34
		1,200	1,137	1,420	1,182	**1,566**	1,496	**1,535**	818	834	789
P90		0	-5	17	-1	33	27	30	-36	-34	-40
		2,444	2,326	2,867	2,424	**3,244**	3,093	**3,177**	1,575	1,611	1,479

Notes: the highlighted cells indicate the two portfolios that yield the highest welfare. The ‘Equivalent Wealth’ corresponds to the wealth at retirement that yields the same utility than the retirement income portfolio. It is calculated as the product of the yearly CEC and the annuity based on the individual’s mortality experience and β parameters.

Table 3: Impact of the state pension: *Equivalent Wealth* without state pension [first row] and difference between the 'Equivalent Wealth' with and without state pension (in $ '000s) for the retirement portfolios presented in Table 1.

		Australian							Dutch		
Income category	Bequest	Nominal Annuity	Indexed Annuity	Phased Withdrawal	Mixed Annuities	Nominal Annuity, Phased Withdrawal	Indexed Annuity, Phased Withdrawal	Third each	Indexed Annuity (DB)	High/Low Annuity	Low/High Annuity
P10		**340**	324	251	**339**	318	305	325	10	10	9
		318	311	314	310	305	304	304	435	436	436
P50	No	**1,035**	988	766	**1,031**	967	929	990	349	357	311
		165	149	175	150	149	142	143	468	478	477
P90		**2,378**	2,274	1,764	**2,371**	2,224	2,139	2,278	1,048	1,068	936
		66	52	106	54	59	50	50	527	543	543
P10		340	324	388	339	**454**	433	**448**	10	10	9
		318	311	410	310	379	381	369	435	436	436
P50	Yes	1,035	988	1,179	1,031	**1,380**	1,317	**1,366**	349	357	311
		165	149	242	150	185	179	170	468	478	477
P90		2,378	2,274	2,711	2,371	**3,175**	3,028	**3,143**	1,048	1,068	936
		66	52	156	54	69	65	34	527	543	543

Notes: the highlighted cells indicate the two portfolios that yield the highest welfare. The 'Equivalent Wealth' corresponds to the wealth at retirement that yields the same utility than the retirement income portfolio. It is calculated as the product of the yearly CEC and the annuity based on the individual's mortality experience and β parameters. The state pension in the Australian case is means-tested as described in Section 2.5 and Appendix A.

State pension

The results in Table 3 show the impact of the state pension on the individual's welfare. The first row of each block representing an income category shows the *Equivalent Wealth* without the state pension, whereas the second row shows the difference between the *Equivalent Wealth* with and without state pension, highlighting the impact of including the state pension for different income categories. We observe that *Equivalent Wealth* without a state pension depends on whether there is a bequest motive or not. However, the inclusion of the state pension has the same nominal impact on the *Equivalent Wealth* across bequest motives.

In the Netherlands, the last three columns, the second pillar accrues pension rights on top of a threshold, commonly set at the level of the state pension. The state pension is paid to everyone who fulfills the residency requirements. We observe that the effect of the state pension increases with the income level but is nominally comparable (second row for each income category). The state pension in The Netherlands is flat, implying that everyone receives the same amount for the same residency. The differences shown in the second row of each block should be the same. However, the assumption that individuals with lower and higher income live on average less and more, respectively, affects these values. Indeed, the richest will receive the payment for a longer period, and will have a higher nominal increase in their *Equivalent Wealth*.

On a relative scale the interpretation differs. The lowest income category draws their retirement income almost solely from the state pension while for the highest percentile it accounts for less than half of its regular retirement income. The effect for the lowest income category is the highest due to the reduced accrued rights on top of the state pension threshold. This is reflected in the *Equivalent Wealth*. Comparing the wealth between the lowest and median percentile indicates that the welfare gains for the median wage are not proportional to their lifetime earnings. Indeed, the lowest income category earns a lifetime income which is about 40% of the median income. However, the wealth for the lowest income is about $\frac{3}{4}$ of the wealth for the median earners. This confirms that the state pension is very efficacious at poverty alleviation for individuals with low lifetime wages.

Table 2 indicated that partial annuitization is still desirable and yields higher gains than sticking to portfolio 1 when the bequest coefficient α is not equal to 0. Our benchmark cases considers that individuals receive a state pension which is means-tested for the Australian institutional setting and flat for the Dutch. Alllowing for our comprehensive means-test, individuals in the Australian setting with the lowest, median and highest income receive roughly 100%, 50% and 5% of the state-pension. Thus, the Australian state pension system provides higher protection to lower income categories.

This is reflected by the second row of Table 3. The difference is largest for the lowest income category and it decreases with income. In particular, the lowest income retiree more than doubles their wealth in the presence of the state pension whereas the increase corresponds to roughly \$ 50,000 over a lifetime. We observe too that the increase is highest for individuals with a phased withdrawal product, both with and without a bequest motive. Overall, the most preferred portfolio includes a nominal annuity and phased withdrawal even when the state pension is considered.

In summary, the results in Table 2 confirm that a highly prescribed institutional setting, such as the Dutch one mandating longevity protection by law, is welfare enhancing when the bequest motive is not considered. Indeed, products offering longevity protection score higher than those including equity exposure and flexibility in both the flexible and prescribed setting. However, the results indicate that individuals are better off with a fair annuity from a defined contribution scheme rather than a defined benefit structure.

4 Sensitivity analysis

4.1 Sensitivity to the risk aversion coefficient and subjective discount factor

Table 4 analyzes the effect of the risk aversion coefficient in our welfare measures. We show the results for three levels of risk aversion coefficient: $\gamma = 2$, 5, and 8. The relative weight of cash-flows at the end of retirement increases with the risk aversion coefficient. The first row shows the percentage variation between the nominal annuity portfolio and the other retirement portfolios. We assess the case with bequest and (means-tested) state pension. Varying levels of risk aversion in the case without bequest changes the nominal value of the *Equivalent Wealth* but the rankings and interpretations are comparable to those of the base case studied in Section 3.

Table 4 shows a mixed effect of an increasing γ. The *Equivalent Wealth* decreases for portfolios with longevity protection (portfolio 1, 2 and 4) and increases for the portfolio 3 invested solely in a phased withdrawal product. The impact of increasing risk aversion coefficients results in a non-monotonic relationship between (γ) and *Equivalent Wealth* for portfolios combining longevity protection and equity exposure. From a welfare viewpoint this contradictory relationship can be explained as follows: we are willing to give up *Equivalent Wealth* or alternatively pay a higher price, for a retirement product guaranteeing an income stream during retirement the more risk averse we are. On the other hand, the phased withdrawal product enhances welfare in the presence of a bequest but is objectively a riskier product since it does not offer a lifelong payment and has equity exposure. In this context, the individual requests a higher initial wealth to offset the increased risk exposure.

Table 4 indicates that the welfare of an individual with a low risk aversion, $\gamma = 2$, has a stable level of *Equivalent Wealth*. The phased withdrawal product, despite the desire to leave a bequest, is associated with a utility loss instead of a gain. The higher weight on earlier cash-flows of this risk aversion coefficient increases the welfare of annuities, especially the nominal, as they have on average a higher payment than the phased withdrawal product, which corresponds to 5% of the wealth during the first 10 years of retirement.

The portfolio with the highest welfare gain for the risk aversion coefficients $\gamma = 5$ and 8 combines a nominal annuity and a phased withdrawal. As we consider the case with a state pension, the desire to have an indexation-linked income is covered by the government, especially at later ages. The higher risk aversion weights give later cash-flows a higher weight. This is especially true for the median and highest percentile. These two groups will either live the same in average as the life table or longer. A longer life will reduce the phased withdrawal capital. However, this will positively affect the means-test, increasing the state pension received by those groups. The combined higher relative weight with a higher survival probability will give more weight to portfolios with phased withdrawal exposure. The reduced state pension payments due to means-test will increase the preference to purchase an indexed annuity compared to the lowest income percentile.

Indeed, the lowest income category, which receives almost a full age pension, can rely on portfolios with a higher exposure to equity risk such as portfolio 3 (full phased withdrawal) and mixed phased withdrawal and nominal annuity. The latter confirms a half/third rule for annuitisation, both from the state and insurance markets, and a third invested in a phased withdrawal product which gives access to flexible payments and access to capital.

The second part of Table 4 shows the sensitivity of our results to the subjective discount factor β for a risk aversion coefficient of $\gamma = 5$. The benchmark case assumes that the individual has a subjective discount factor which coincides with the real risk free rate discount factor of 1.5%. We study also $\beta = 0.991$ and 0.98, a higher and lower discounting factor respectively. The β coefficient reflects the degree of impatience. A higher coefficient, reflecting a lower discounting rate, indicates that individuals value later cash-flows *almost* as much as they value payments in early retirement. This translates to higher *Equivalent Wealth* in all scenarios.

The subjective discounting factor does not affect the overall interpretation of our results but does yield slightly different preferences. For instance, if $\beta = 0.98$ or $\beta = 0.991$, that is, if the discounting rate is higher or lower than the real risk free rate, the ranking of the portfolios varies slightly for the lowest and highest income quantiles. The second most desired portfolio will have a higher proportion in indexed annuities than the base case.

4.2 Sensitivity to the pricing of the annuity: mortality differentials and loadings

Table 5 show that loadings and mortality differentials do not affect the rankings of the portfolios. Individuals are still better off with a nominal annuity or a portfolio mixing indexed and nominal annuities if the bequest coefficient is zero. They would prefer a portfolio with either a third in each product or a half in the nominal annuity and a half in the phased withdrawal product. The results in Table 5 confirm that our results are robust to *reasonable* loading levels and mortality differentials.

However, the *Equivalent Wealth* varies. The wealth decreases with the loading parameter and increases with the mortality differentials. Fixed nominal and indexed annuities are commonly affected by loadings which increase the value of the annuity factor used to convert the pension wealth into a regular payment stream. These loadings are used to finance non-hedgeable risks such as idiosyncratic and systematic longevity risk. Whereas reasonable loading levels help cover fees inherent to running an insurance business (Mitchell et al., 1999), a loading of 20% yields an average lifetime loss of \$ 140,000 if purchasing a nominal annuity.

The loading level closes the welfare gap between purchasing a phased withdrawal product and a nominal annuity. The results show that higher loadings reduce the welfare of annuity-like products, bringing these closer to the welfare levels associated with phased withdrawal products in the absence of a bequest motive. The effect of loadings is mixed in portfolios combining annuities and phased withdrawals as the former is affected by the additional fees whereas the latter is not.

Individuals living longer than the life table used in the annuity pricing, $\eta > 1$, will gain from purchasing annuities as they will receive payments on average during a longer period. The lifetime gain in (unexpected) additional state pension and nominal annuities payments can reach \$ 283,000. Individuals without bequest motives will be best off with products offering longevity insurance. When the individual values accumulating wealth, for precautionary savings or bequest, at least a third of the portfolio should be invested in a phased withdrawal product. In practice, for the median individual, which receives roughly half of the state pension after means-test, the preferred portfolio implies more than three quarters in longevity production with around a quarter in a product offering flexibility.

Table 4: Sensitivity to the risk aversion coefficient: 'Equivalent Wealth' (in $ '000s) [second line].

Income category	Risk aversion (γ)	Australian							Dutch		
		Nominal Annuity	Indexed Annuity	Phased Withdrawal	Mixed Annuities	Nominal Annuity, Phased Withdrawal	Indexed Annuity, Phased Withdrawal	Third each	Indexed Annuity (DB)	High/Low Annuity	Low/High Annuity
P10	2	**683**	676	623	680	667	662	**691**	468	468	468
	5	659	635	799	649	**832**	814	**817**	445	446	445
	8	639	604	**792**	624	**773**	749	691	430	431	429
P50	2	**1,219**	1,206	1,104	**1,218**	1,190	1,173	1,204	859	862	850
	5	1,200	1,137	1,420	1,182	**1,566**	1,496	**1,535**	818	834	789
	8	1,184	1,086	1,485	1,152	**1,597**	**1,537**	1,483	789	816	746
P90	2	2,453	2,449	2,253	**2,470**	2,438	2,408	**2,460**	1,653	1,658	1,626
	5	2,444	2,326	2,867	2,424	**3,244**	3,093	**3,177**	1,575	1,611	1,479
	8	2,436	2,240	2,942	2,387	**3,365**	**3,264**	3,127	1,521	1,578	1,380
	Subjective discount factor β										
P10	0.98	613	590	754	603	757	**761**	**758**	415	416	414
	0.9855	659	635	799	649	**832**	814	**817**	445	446	445
	0.991	703	679	872	693	**874**	870	**873**	477	478	476
P50	0.98	1,112	1,049	1,276	1,091	**1,414**	1,373	**1,386**	762	779	734
	0.9855	1,200	1,137	1,420	1,182	**1,566**	1,496	**1,535**	818	834	789
	0.991	1,268	1,207	1,479	1,251	**1,622**	1,580	**1,584**	876	892	846
P90	0.98	2,252	2,129	2,546	2,225	**2,910**	**2,873**	2,859	1,466	1,503	1,374
	0.9855	2,444	2,326	2,867	2,424	**3,244**	3,093	**3,177**	1,575	1,611	1,479
	0.991	2,560	2,450	2,995	2,547	**3,337**	**3,292**	3,272	1,687	1,722	1,588

Notes: The risk analysis of the risk aversion coefficient γ assumes a subjective discount factor of $\beta = 0.9855$. The sensitivity analysis to the β coefficient assumes a risk aversion coefficient of $\gamma = 5$. The 'Equivalent Wealth' corresponds to the wealth at retirement that yields the same utility than the retirement income portfolio. It is calculated as the product of the yearly CEC and the annuity based on the individual's mortality experience and β parameters.

Table 5: Sensitivity to the loadings and mortality differentials: 'Equivalent Wealth' (in $ '000s) [second line].

		Australian							Dutch		
Loading (l)	Bequest	Nominal Annuity	Indexed Annuity	Phased Withdrawal	Mixed Annuities	Nominal Annuity, Phased Withdrawal	Indexed Annuity, Phased Withdrawal	Third each	Indexed Annuity (DB)	High/Low Annuity	Low/High Annuity
0%		**1,186**	1,124	930	**1,167**	1,101	1,055	1,117	818	834	789
10%	No	**1,109**	1,050	930	**1,091**	1,058	1,016	1,064	818	834	789
20%		**1,046**	989	930	**1,028**	1,023	984	1,021	818	834	789
0%		1,186	1,124	1,376	1,167	**1,508**	1,470	**1,479**	818	834	789
10%	Yes	1,109	1,050	1,376	1,091	**1,475**	1,470	**1,442**	818	834	789
20%		1,046	989	1,376	1,028	**1,510**	1,432	**1,439**	818	834	789
Mortality differentials (η)	Bequest										
0.75		**903**	851	705	**887**	836	799	848	621	635	597
1.00	No	**1,186**	1,124	930	**1,167**	1,101	1,055	1,117	818	834	789
1.25		**1,469**	1,397	1,155	**1,448**	1,365	1,311	1,387	1,015	1,034	980
0.75		903	851	1,061	887	**1,155**	1,119	**1,124**	621	635	597
1.00	Yes	1,186	1,124	1,376	1,167	**1,508**	1,470	**1,479**	818	834	789
1.25		1,469	1,397	1,714	1,448	**1,865**	1,831	**1,850**	1,015	1,034	980

Notes: The risk analysis of the loading l assumes no differential mortality. The sensitivity analysis to the mortality differentials assumes a zero loading parameter. The 'Equivalent Wealth' corresponds to the wealth at retirement that yields the same utility than the retirement income portfolio. It is calculated as the product of the yearly CEC and the annuity based on the individual's mortality experience and β parameters.

5 Conclusion

We have assessed portfolios of retirement income products for the Australian and Dutch retirement systems allowing for income levels and a range of factors that are expected to impact the comparison.

We include the impact of means-testing the first pillar pension on the welfare of representative Australians from three income categories. The state pension meets its purpose by increasing the welfare of lower socio-economic categories. Furthermore, we observe that for all income categories the state pension reduces the demand for indexed annuities since it is an inflation linked payment.

In the Dutch setting purchasing a 'high-low' pension arrangement provides a higher pension during the first five years of retirement and is preferred under our preference assumptions. We show that a flat state pension with 'high-low' pension is comparable in terms of CEC to a portfolio evenly split between a nominal annuity and a phased withdrawal on top of a means-tested indexed pension. The 'high-low' arrangement provides a similar welfare as investing a share of income in a flexible phased withdrawal product.

Our analysis, for individuals with varying income, mortality and risk attitudes, shows that there is no a product, or combination of products which suits everyone. An individual will enhance their welfare with a combined exposure to lifetime payments, either via direct annuitization or a (means-tested) state pension, and equity exposure.

Mortality differentials and loadings slightly affect the ranking of portfolios but yield consistently the same two portfolios as the most preferred. When individuals do not value bequests, they prefer an annuity, but the welfare diminishes as the loadings increase or their life expectancy is less than the average population. On the other hand, individuals with a bequest motive prefer portfolios with exposure to liquidity and flexibility by increasing the proportion in phased withdrawals. Interestingly, for some risk and bequest preferences we observe that the highest income percentile would be better off with a portfolio combining phased withdrawals and annuities, even in the presence of a means-tested pension.

From a policy perspective, this analysis suggests that the Dutch institutional setting provides important lessons for improving portfolio choice. Individuals are better off with products offering longevity protection in the absence of a bequest. However, with a bequest motive, individuals experience a welfare loss if their retirement wealth is fully annuitized. Having liquid wealth can serve more than one purpose. It can serve to self-insure against unexpected health expenditures, such as long term care and living longer than expected (Peijnenburg et al., 2017; Lockwood, 2014) or financing a certain standard of living throughout retirement (Alonso-García et al., 2017).

In practice, retirement saving choices, in both the accumulation and decumulation phase, are strongly influenced by government policy. This is commonly done by mandating, directing choice with tax policies or by nudging. Examples of this include the requirement to contribute a minimum level to a superannuation fund, to have a minimum withdrawal amount or to purchase a specified retirement income product, with tax favorable treatment or by implementing defaults. The aim is to enhance an individual's welfare and prevent them from making choices that can potentially reduce their lifetime utility and to also reduce government welfare spending by ensuring tax preferred retirement savings are used for consumption rather then bequest, as in the Dutch setting.

Our approach assumes that individuals consume the full payout associated with their retirement income products. Asher et al. (2017) analyze eight years of Centrelink data[21] and show that consumption stays low on average, even among the wealthier individuals who receive a full or partial state pension payment. In particular they show that poorer retirees appear to consume even less than the first pillar state pension payment. Similarly, Van Ooijen et al. (2015) find that elderly Dutch on average keep large amounts of assets even at a very old age, leaving large bequests. This will shift the weight away from consumption to bequest in our analysis, resulting in an increased preference for more flexible retirement portfolios.

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[21] Centrelink is the Australian government agency which delivers a range of social security government payments.

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A The Australian means-tested state pension

The state pension at age x and year y denoted as SP_x paid is the minimum of the state pension after applying the asset test, SP_x^{AT}, and the state pension after applying the income test, SP_x^{IT}:

$$SP_{x,y} = \min\left(SP_{x,y}^{AT}, SP_{x,y}^{IT}\right) \tag{A.1}$$

The state pension after applying the asset test, $SP_{x,y}^{AT}$ is calculated as follows:

$$SP_x^{AT} = \max\left(0, SP_x - \max\left(0, k_x^{AT} - A_x\right) \cdot tr^{AT}\right) \tag{A.2}$$

where $SP_{x,y}$ is the state pension at the time of calculation, $k_{x,y}^{AT}$ is the wealth of the individual at age x in year y for asset test purposes. The wealth for asset test purposes differs from the liquid account balance $k_{x,y}^{PW}$ in Equation (2.14) since it also accounts for the underlying value of the annuities even though they do not include a bequest:

$$k_x^{AT} = \max\left(0, \theta_1 \cdot k_{x_r} - \sum_{j=x_r}^{x} C_j^A\right) + \max\left(0, \theta_2 \cdot k_{x_r} - \sum_{j=x_r}^{x} C_j^{iA}\right) + \max\left(0, k_x^{PW}\right), \quad \text{(A.3)}$$

A_x is the asset threshold under which the individual receives a full state pension payment after applying the asset test. As of 1 January 2017 it is set equal to \$250,000 for single homeowners and \$375,000 for a couple who owns the home they live in (Department of Human Services, 2017b).

Finally, tr^{AT} is the fixed taper rate for the pension assets test. According to the Department of Human Services (2017b) the state pension is reduced every fortnight by \$3 per \$1,000 over the asset threshold A_x. This corresponds to an annualized taper rate of 0.078. The state pension after applying the income test, $SP_{x,y}^{IT}$ is calculated as follows:

$$SP_x^{IT} = \max\left(0, SP_x - \max\left(0, C_x^{IT} - I_x\right) \cdot tr^{IT}\right), \quad \text{(A.4)}$$

where C_x^{IT} is the income of the individual for income test purposes. The income consists of the sum of retirement income payments as well as the 'deemed' return on assets. Department of Human Services (2017a) does not account for the real observed return on assets but assumes a certain rate of return, which corresponds to the 'deeming rate'. The income C_x^{IT} is given as follows:

$$\begin{aligned} C_x^{IT} = & \min\left(\theta_1 \cdot k_{x_r} + \theta_2 \cdot k_{x_r} - \sum_{j=x_r}^{x} C_j^A - \sum_{j=s}^{x} C_j^{iA} + k_x^{PW}, D_x\right) \cdot 1.75\% \\ & + \max\left(\theta_1 \cdot k_{x_r} + \theta_2 \cdot k_{x_r} - \sum_{j=x_r}^{x} C_j^A - \sum_{j=x_r}^{x} C_j^{iA} + k_x^{PW} - D_x, 0\right) \cdot 3.25\% \\ & + C_x^A + C_x^{iA} + C_x^{PW}, \end{aligned} \quad \text{(A.5)}$$

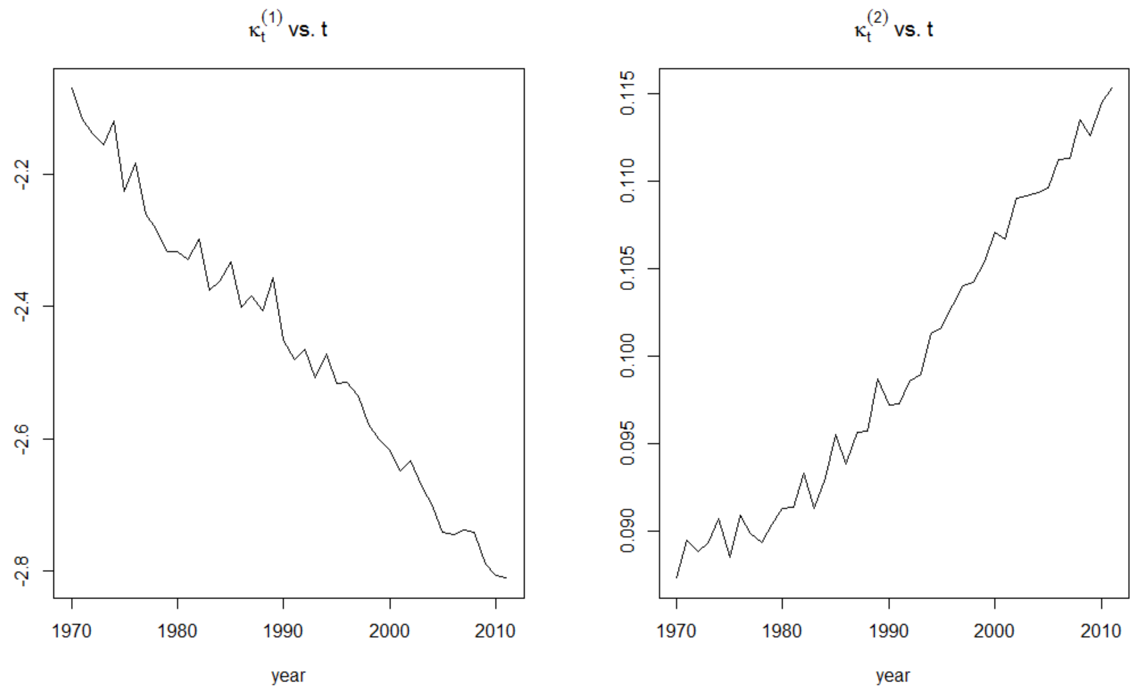
where D_x is the asset threshold for deeming purposes. The income test assumes that any capital under the threshold earns 1.75% per annum, and any capital above the threshold earns 3.25% per annum. For a single this threshold is set to \$49,200 while for a couple it is set to \$81,600 (Department of Human Services, 2017c), I_x is the income threshold which is set as \$164 per fortnight or equivalent to \$4,338 on a yearly basis, and tr^{IT} is the taper rate for the income asset test. According to Department of Human Services (2017c) the state pension is reduced by 50 cents every fortnight for each dollar of income over 164\$. This yields to an annualized taper rate of 0.5.

We assume that the state pension and the various thresholds increase during retirement at the inflation rate as follows $SP_x = SP_{x_r}(1+\delta)^{x-x_r}$.

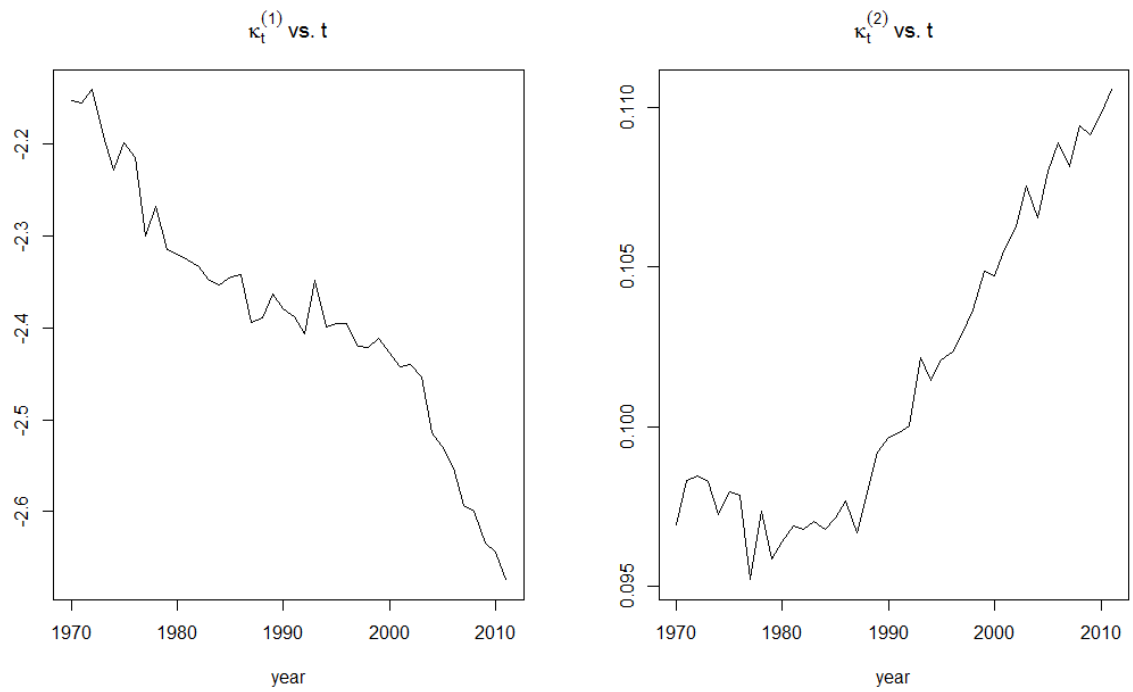
B Estimation of the stochastic mortality model

Figure 1: Cairns et al. (2006) Parameter Estimates.

Australia



The Netherlands



Notes: the top panel plots the parameter estimates for Australia while the lower panel shows the parameter estimates for The Netherlands. $\kappa_y^{(1)}$ shows the period-related effect and $\kappa_y^{(2)}$ is the period-dependent factor interacting with the difference between the age considered and the average age, that is $(x - \overline{x})$. Here the subscript t indicates the year which we denoted y.

We estimate the Cairns-Blake-Dowd (CBD) model presented in Section 2.2 using the Australian and Dutch data from the Human Mortality Database (2014, 2015). The calibration procedure is done in R using the following packages: demography (Hyndman et al., 2017) and StMoMo (Villegas et al., 2016). First we use the 'demography' package to extract the death counts $D_{x,y}$ for the age x at time y and the population's exposure to risk $E_{x,y}$. In our study we use the data on the total population and do not differentiate by gender. The Cairns et al. (2006) model is known to fit well old-age mortality and calibrate only between the age of 55 to $\omega = 110$.

We fit the data for the period from 1970 to 2011. In the estimation procedure we put zero weight to cohorts with less than 3 observations. Figure 1 shows the parameter estimates for the CBD model for Australia and The Netherlands. The top and lower panel plots the parameter estimates for Australia and The Netherlands respectively. We observe that the logarithm of the mortality rate in Equation 2.4 decreases with the time-period component $\kappa_y^{(1)}$ and increases the second period component $\kappa_y^{(2)}$ for ages higher than the average for the age interval studied, $x > \overline{x}$, and decreases for ages lower than $\overline{x}$.

We forecast the future mortality rate following Cairns et al. (2006) by assuming that the period indexes $\kappa_y^{(i)}$, $i = 1, 2$ evolve under a multivariate random walk with drift as follows:

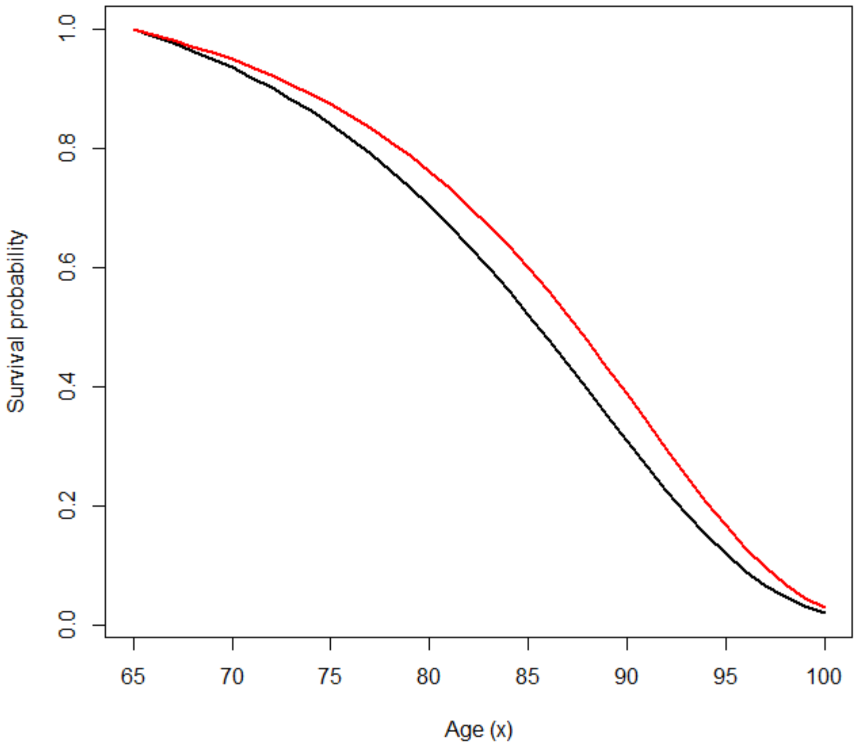
$$\begin{pmatrix} \kappa_y^{(1)} \\ \kappa_y^{(2)} \end{pmatrix} = \begin{pmatrix} \delta_1 \\ \delta_2 \end{pmatrix} + \begin{pmatrix} \kappa_{y-1}^{(1)} \\ \kappa_{y-1}^{(2)} + \end{pmatrix} + \zeta_y^{\kappa} \tag{B.1}$$

$$\zeta_y^{\kappa} \sim N(0, \Sigma) \tag{B.2}$$

where $\delta = (\delta_1, \delta_2)'$ is a vector of drift parameters, ζ_y^{κ} is a multivariate white noise with a variance-covariance matrix of Σ. The forecasting is completed as well using the StMoMo R package (Villegas et al., 2016). Figure 2 shows the forecasted survival probability for Australia (black-line) and Australia (red-line) for a cohort retiring at 65. We observe that the survival probability of Dutch, black line, is lower than the survival probability of Australians, red line, for all ages considered.

Despite the difference in the curve, both life tables yield similar life expectancy values: Australians have a life expectancy at 65 of 21.8 years whereas the Dutch have a life expectancy of 20.20 at retirement. The higher forecasted life expectancy for Australians aligns with life expectancy values based on observed historical data (OECD, 2017b).

Figure 2: Survival probability for ages 65 to 110 for The Netherlands (black line) and Australia (red line) contingent on being alive at age 65.



Notes: the red color corresponds to Australia and the black color corresponds to The Netherlands. The probability shown is based on the average of 10000 Monte Carlo simulations.